Appendix A

Modeling Report

Cedar Creek

WBID 1926

Nutrients, BOD and Dissolved Oxygen

March 2013

Region4 serving the southeast

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1. Watershed Description

Cedar Creek (WBID 1926, Figure 1) is a tributary basin to the Braden River. Braden River drains the southern portion of the Manatee River watershed in Manatee County. Cedar Creek is a small basin (5.0 km^2) in the Manatee River watershed. The creek enters the Braden River approximately 1.5 km upstream of Ward Lake, the primary water supply reservoir for the City of Bradenton. Land use in the Cedar Creek basin is predominantly urban (76 percent) consisting of residential housing and golf course land uses. Cedar Creek, as a tributary to Braden River and Ward Lake is designated as a Class I potable water supply by the Florida Department of Environmental Protection.

Changes in land use in the Cedar Creek basin are from urbanization and subsequent stormwater management. These changes in land use are reflected in the hydraulic modification of the basin such that wetlands have been converted to small stormwater ponds at the neighborhood scale.

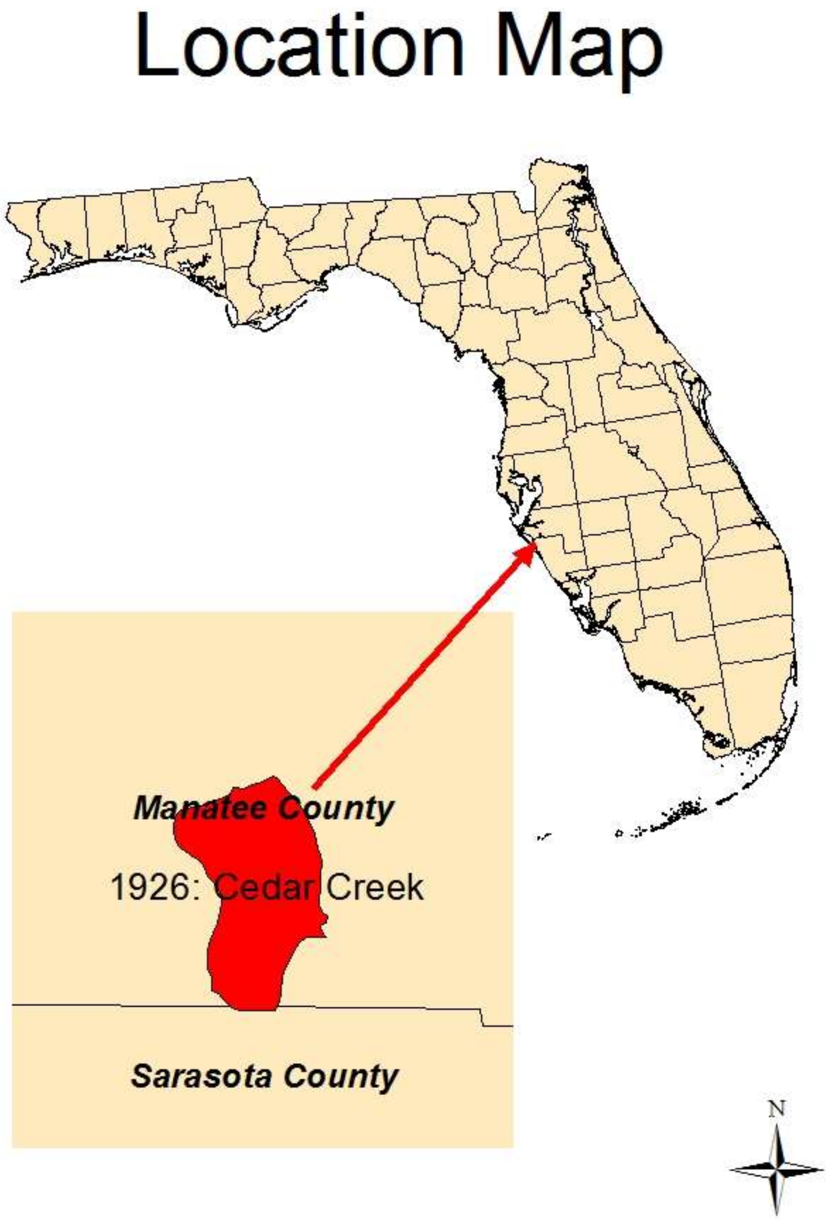

Figure 1 Location Map for WBID 1926

The landuse distribution for the Cedar Creek watershed is presented in Figure 2. The watershed is predominantly urban.

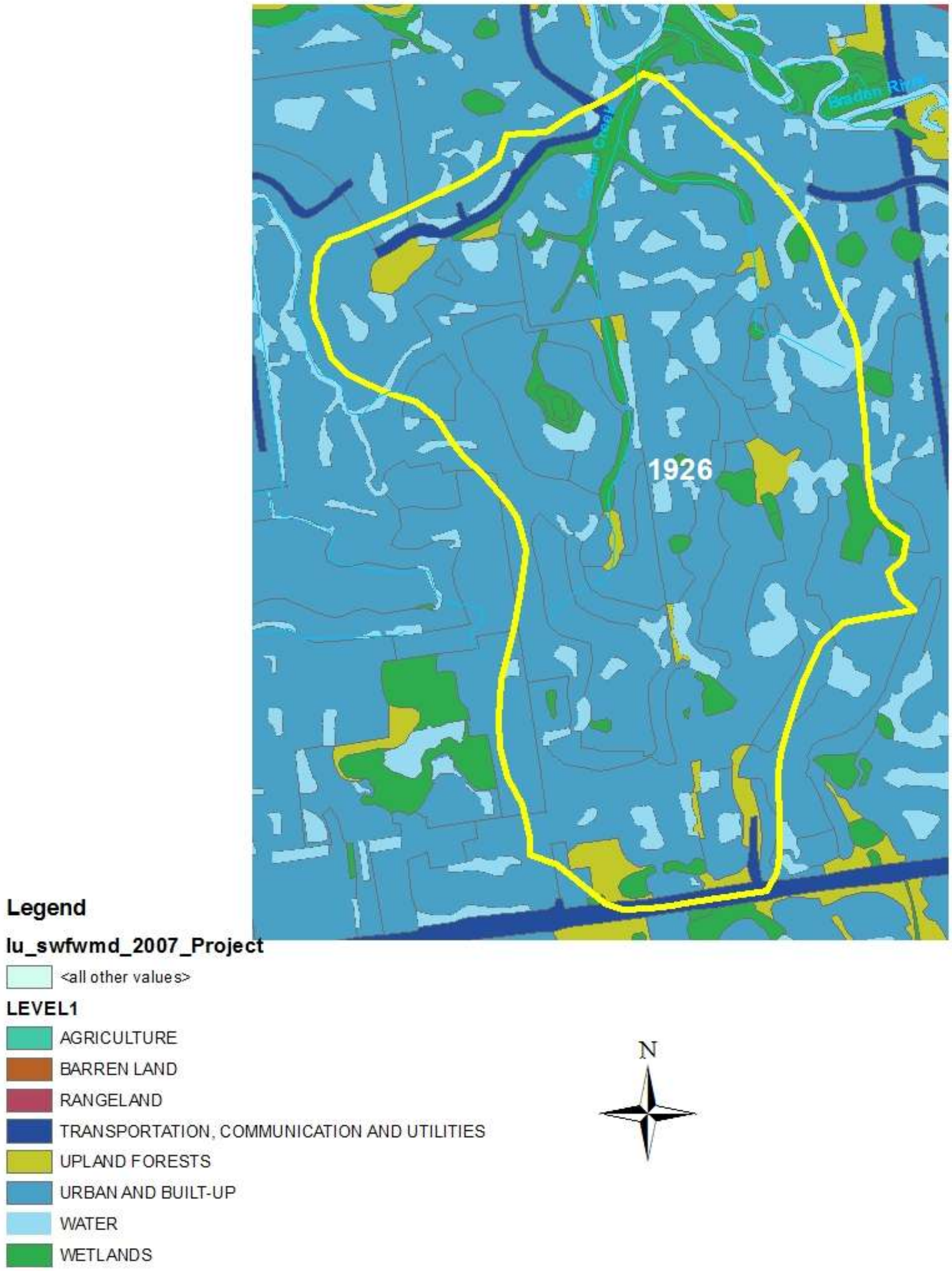

Figure 2 Landuse Distribution for Cedar Creek watershed

2. TMDL Targets

The TMDL reduction scenarios will be done to achieve a dissolved oxygen concentration of 5 mg/L within the Cedar Creek watershed or establish the natural condition.

3. Modeling Approach

A coupled watershed and water quality modeling framework was used to simulate biological oxygen demand (BOD), nutrients (total nitrogen and total phosphorus), and chlorophyll a (Chla) and dissolved oxygen (DO) for the time period of January 2002 through July 2008. The watershed model provides daily runoff, nutrient and BOD loadings from the watershed. The predicted results from the LSPC model served as boundary conditions to the receiving in-stream model Water Quality Analysis Simulation Program (WASP 7.5) (USEPA, 2009). The WASP model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. Both LSPC and WASP were calibrated to current conditions and used to simulate a natural condition. The WASP model was used to determine the percent reduction in loadings that would be needed to meet water quality standards.

3.1. Cedar Creek Watershed Model

The goal of this watershed modeling effort is to estimate runoff (flow), total nitrogen (TN), total phosphorus (TP) and BOD loads and concentrations from the upstream watersheds flowing into Cedar Creek. The Loading Simulation Program C++ (LSPC) was used as the watershed model.

LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by EPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, the U.S. Environmental Protection Agency (EPA) Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox.

3.1.1. Watershed Delineation and Landuse

The surrounding watershed that drains directly to Cedar Creek is presented in Figure 3. The LSPC model includes 5 sub-basins. The WBID does not have a flow station; hence, the model uses a drainage basin ratio method to calibrate flows at the mouth of Cedar Creek to a nearby gage in the Braden River.

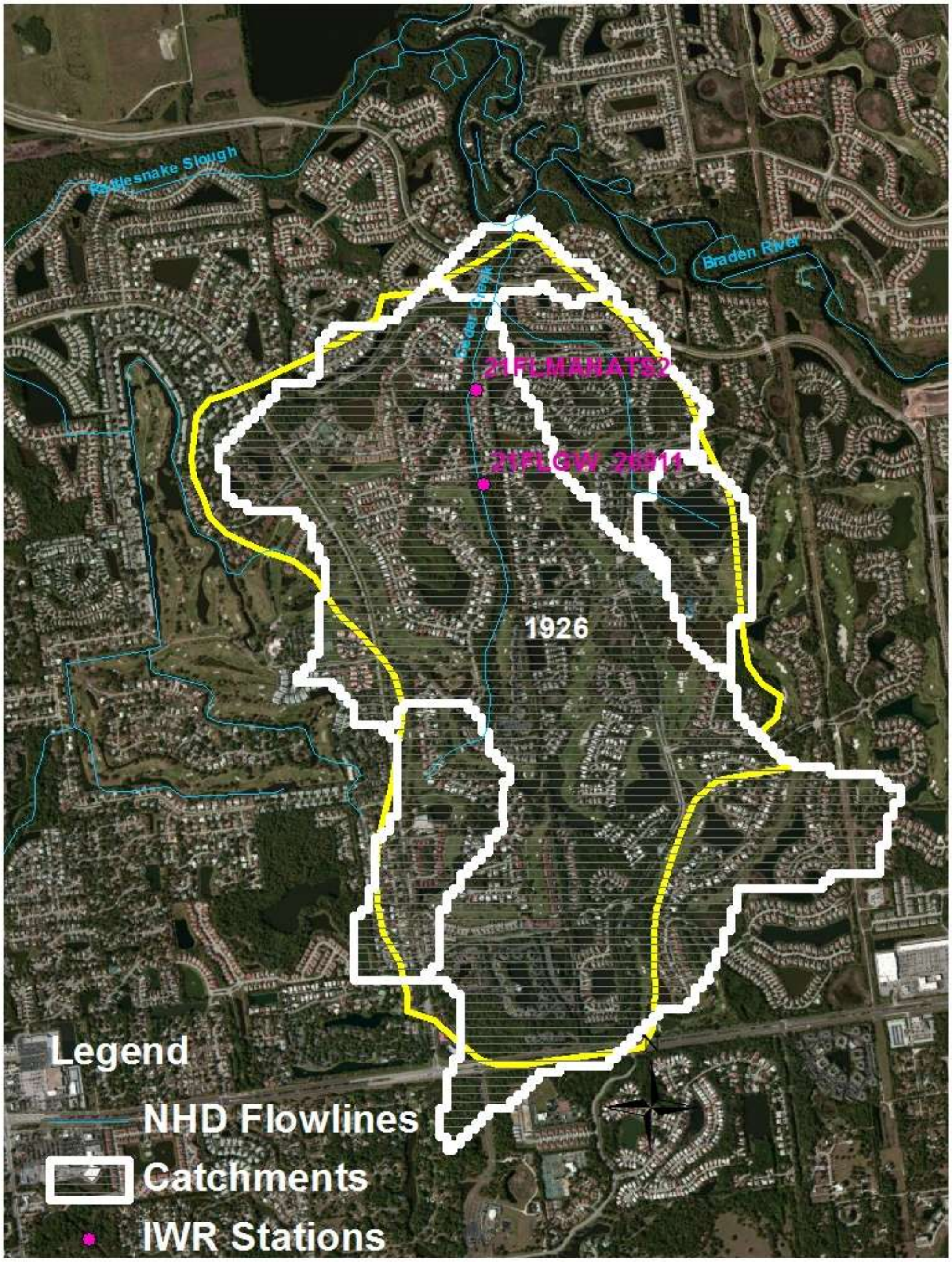

Figure 3 Cedar Creek Watershed Delineation

3.2. Cedar Creek Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events for the current and natural conditions.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station 086880.

3.2.2. BOD and Nutrient Loadings

Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 1). The initial EMC values were derived for each landuse type from a study by Harper and Baker (2003) and then calibrated to all data available for the watershed. Wetland EMCs were derived from the study of Reiss et.al, (2009). The study summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida.

Table 1 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen	Total Phosphorus	BOD
Upland Forest	1.09	0.05	1.2
Transportation	2.23	0.27	6.7
Urban Area	1.64	0.38	4.3
Water	1.6	0.07	1.6
Wetlands	1.01	0.09	2.6

BOD and nutrient watershed runoff were determined using EMCs for surface water runoff and interflow runoff and baseflow concentrations for groundwater flow. Table 2 provides the annual average total nitrogen, total phosphorus and BOD loads for the simulated period 1/2002 through 7/2008. It is these loadings that the TMDL load reduction will be calculated from.

Table 2 Cedar Creek Nutrient Loads (1/2002-7/2008)

	WBID 1926	
Constituent	**WLA (kg/yr)**	**LA (kg/yr)**
Total Nitrogen	NA	7413
Total Phosphorus	NA	948
BOD	NA	13349

3.3. Cedar Creek Water Quality Model

The Cedar Creek WASP water quality model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. A five segment WASP water quality model was setup to include the Cedar Creek basin.

3.3.1. WASP Model

The WASP water quality model uses net flows to simulate flow and velocity and the basic eutrophication module to predict dissolved oxygen and Chlorophyll a responses to BOD, total nitrogen and total phosphorus loadings. Widths and depths were taken from the National Hydraulic Dataset (NHD) published by the United States Geologic Survey. These widths and depths were then modified based on satellite imagery and best judgment. Table 3 provides the basic kinetic rates used in the model.

Table 3 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	Covar Method
Sediment Oxygen Demand (g/m2/day)	1.0
Phytoplankton Maximum Growth Rate Constant @ 20 °C (per day)	3
Phytoplankton Carbon to Chlorophyll Ratio	60
BOD (1) Decay Rate Constant @ 20 °C (per day)	0.15
Ammonia, nitrate, phosphorus rates @ 20 °C (per day)	0.2, 0.001, 0.1

Table 4 provides a comparison of predicted annual average concentrations (WASP segment 2) versus the annual average concentrations of the measured data at the IWR station 21FLMANA-TS2 for 2003 through 2009 (model was run from 1/2002 through 7/2008).

Table 4 Existing Condition Observed and Predicted Annual Average Concentrations (2003-2009)

Constituent	Simulated	Observed	Error
BOD (mg/L)	2.23	2.53	-11.7%
Chlorophyll a (ug/L)*	2.79	8.05	-65.3%
DO (mg/L)	5.73	5.70	0.5%
Total Nitrogen (mg/L)	1.34	1.25	7.2%
Total Phosphorus (mg/L)	0.21	0.18	16.7%

* - Observed Chl-a is uncorrected

Figure 4 through Figure 8 depict the calibration which compares the observed versus the predicted concentrations. Figures 9 and 10 depict flow calibration.

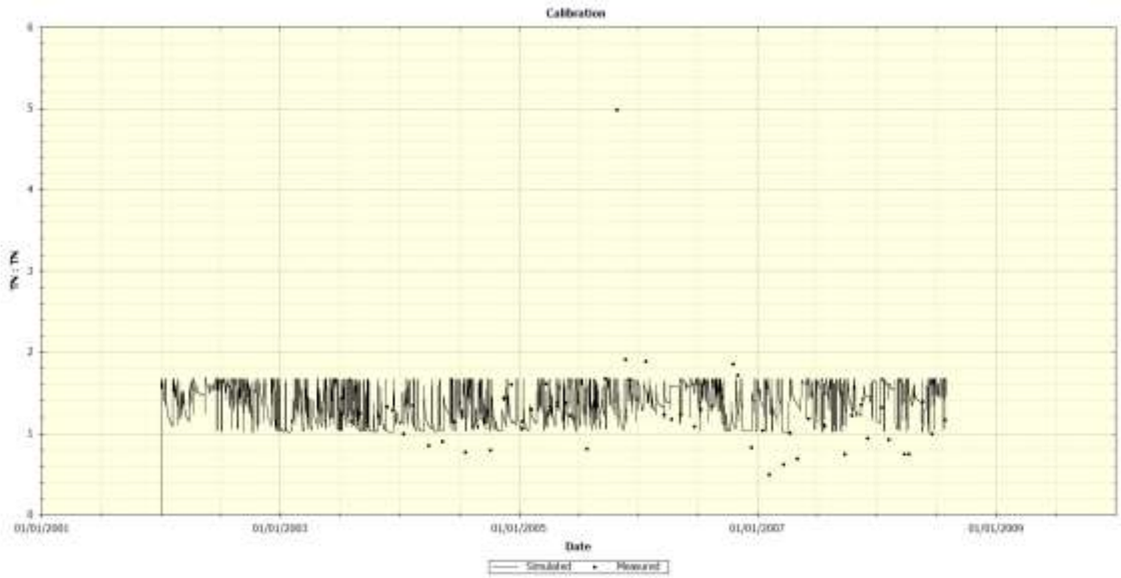

Figure 4 WASP Calibration for Total Nitrogen

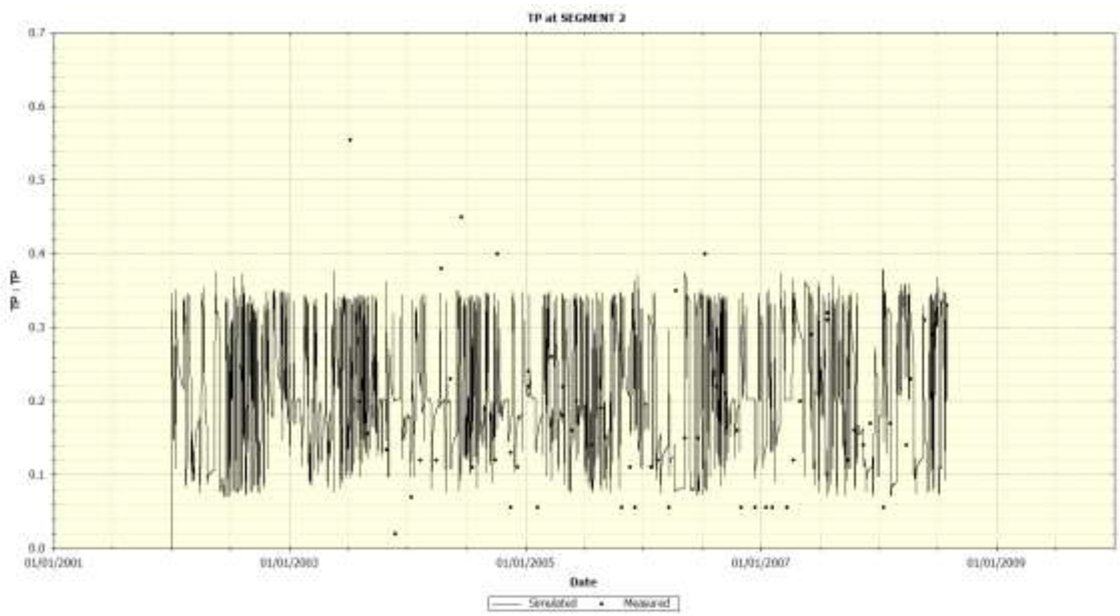

Figure 5 WASP Calibration for Total Phosphorus

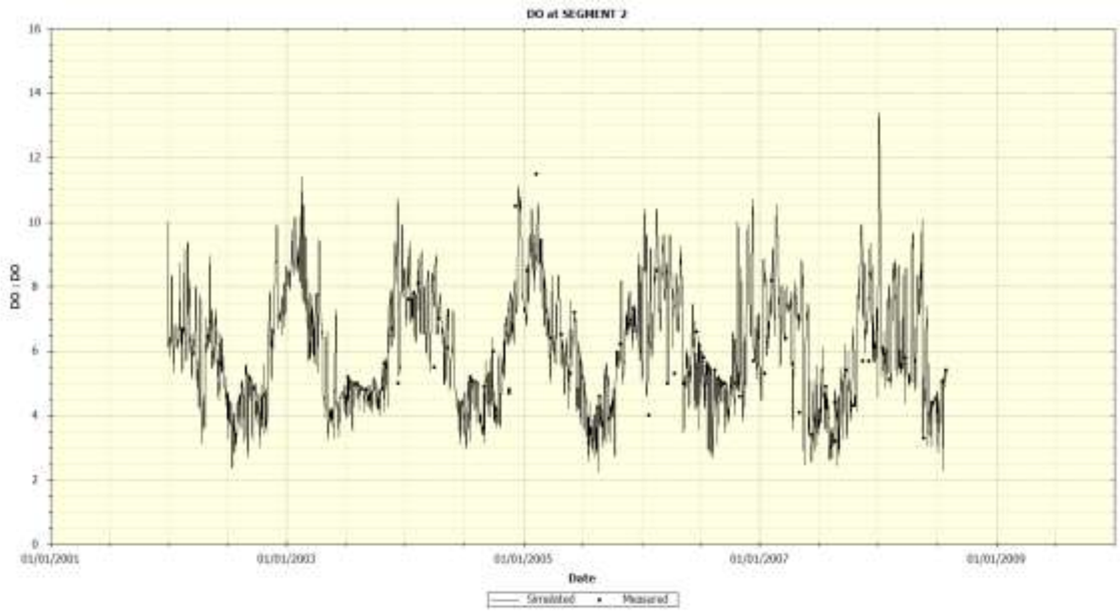

Figure 6 WASP Calibration for Dissolved Oxygen

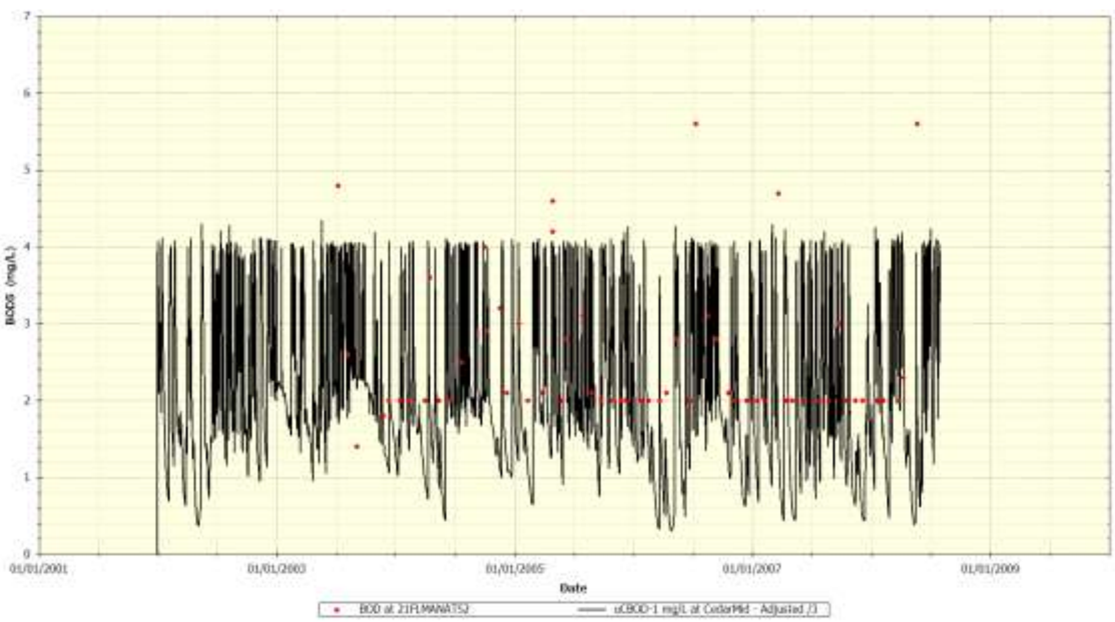

Figure 7 WASP Calibration for BOD5

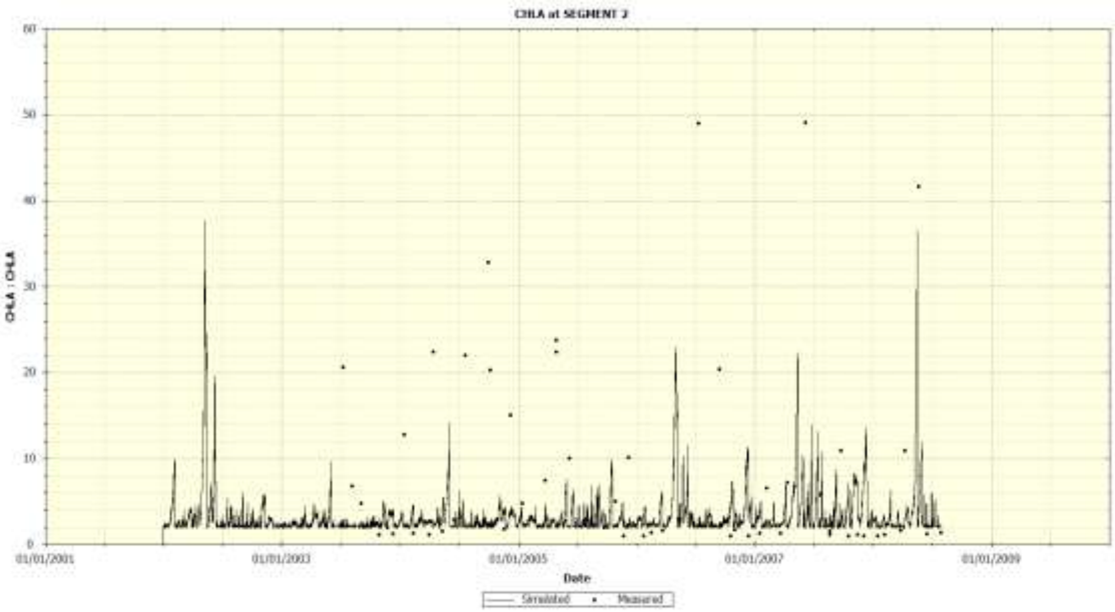

Figure 8 WASP Calibration for Chlorophyll a

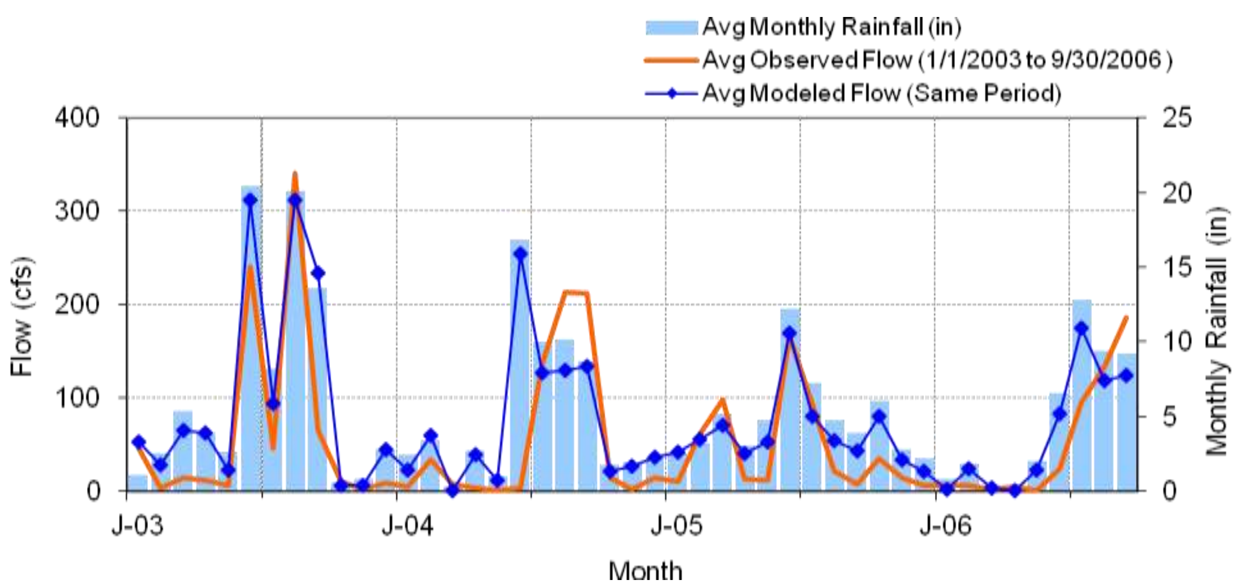

Figure 9 WASP Calibration for Monthly Average Flow

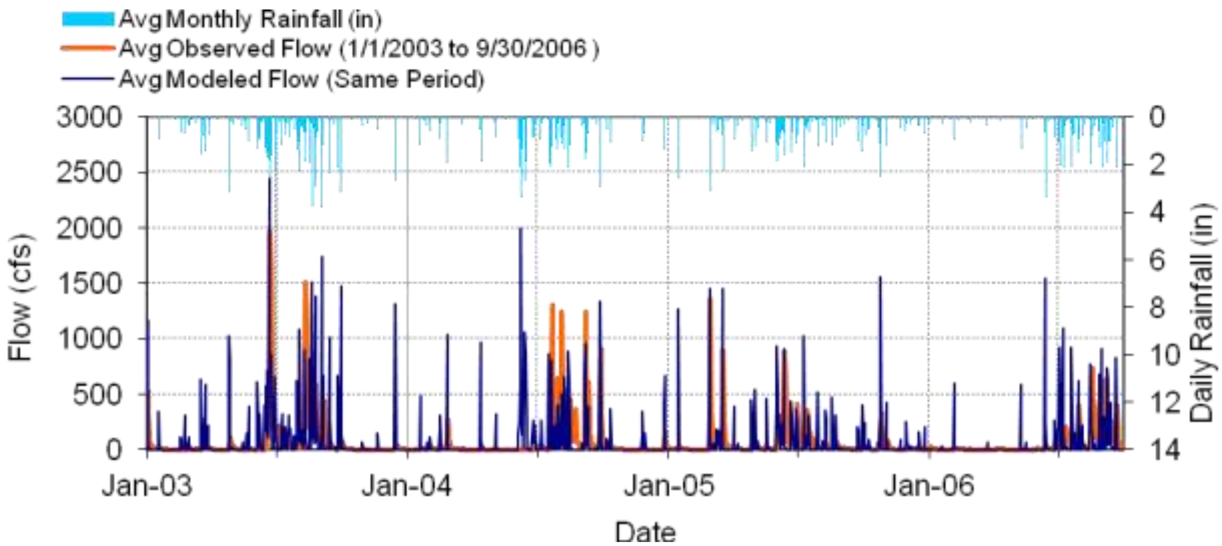

Figure 10 WASP Calibration for Flow

4. Modeling Scenarios

Using the calibrated watershed and water quality models, two potential modeling scenarios will be developed. The calibrated model was first used to predict water quality conditions under natural condition (without point sources and returning landuses back to upland forests and wetlands). A second scenario will be developed if water quality standards can be met under natural conditions (balanced flora and fauna, dissolved oxygen greater than 5 mg/L); loads would be reduced from the current conditions until standards are met (balanced flora and fauna, dissolved oxygen greater than 5 mg/L).

4.1. Natural Condition Analysis

Cedar Creek sub-basins and upstream land uses were changed from impacted lands to upland forest and wetlands land uses. LSPC was then used to simulate the natural condition nutrient loads (Table 5) which were inputted in to WASP model.

	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
Total Nitrogen	NA	1,641
Total Phosphorus	NA	101
BOD	NA	2,788

Table 5 Annual Average Loadings for Natural Condition

Table 6 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Cedar Creek still would not achieve the dissolved oxygen standard of 5 mg/l (Figure 11).

Natural Condition

Constituent	Natural
BOD (mg/L)	1.11
Chlorophyll a (ug/L)	2.89
DO (mg/L)	5.91
Total Nitrogen (mg/L)	1.10
Total Phosphorus (mg/L)	0.06

Table 6 Simulated Annual Average Concentrations Under Natural Conditions

4.2. TMDL Load Reductions

Because water quality standards cannot be met under natural conditions (Figure 11) no other scenarios were conducted. The TMDL will be set to the natural conditions.

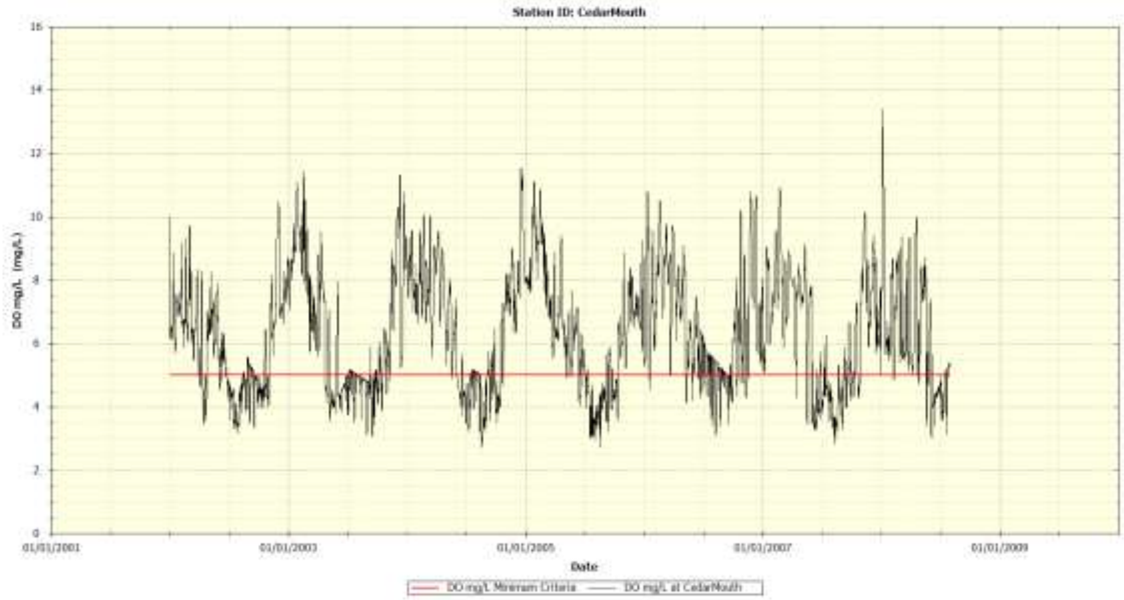

Figure 11 DO Concentration Time Series under Natural Condition

5. TMDL Determination

The TMDL load reduction was determined by reducing the current conditions to the natural conditions. The annual average loadings are given in Table 7 along with the prescribed load reductions.

Table 7 TMDL Determination

	Current Condition		TMDL Condition		MS4	LA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction
BOD	NA	5,079	NA	2,787	45%	45%
Total Nitrogen	NA	2,139	NA	1,682	21%	21%
Total Phosphorus	NA	421	NA	101	76%	76%

6. References

Harper, H. H. and D.M. Baker. 2003. Evaluation of Alternative Stormwater Regulations for Southwest Florida. Environmental Research & Design, Inc. Orlando, FL.

Reiss, K. C., J. Evans and M.T. Brown. 2009. Summary of the Available Literature on Nutrient Concentrations and Hydrology for Florida Isolated Wetlands. Howard T. Odum Center for Wetlands, Department of Environmental Engineering Sciences, University of Florida, Water Management District, Gainesville, FL.

PBSJ. 2007. Peace River Cumulative Impact Study. Final Report Submitted to Florida Department of Environmental Protection. Tallahassee, FL.